Primary treatment choice over time and relative survival of prostate cancer patients: influence of age, grade, and stage

Matthes, Katarina L ; Limam, Manuela ; Dehler, Silvia ; Korol, Dimitri ; Rohrmann, Sabine

Abstract: BACKGROUND: The aim of this study was to assess associations of stage, grade, and age with the primary treatment of prostate cancer (PCa) patients comparing the incidence years 2000/2001 and 2012/2013, and to estimate the relative survival (RS) for patients diagnosed in 2000/2001. METHODS: We included 1,541 men diagnosed in 2000/2001 and 1,605 men diagnosed in 2012/2013. Multiple imputation methods were applied to missing data for stage and grade. Multinomial logistic regression analyses were used to explore the associations of stage, grade, and age with treatment. RS was estimated using the Ederer II approach. RESULTS: In 2000/2001, older patients were more likely to choose active surveillance (AS)/watchful waiting (WW) or to receive androgen deprivation therapy (ADT) compared to surgery; in 2012/2013, this association was only observed for ADT but not for AS/WW. In 2000/2001, the overall 1-, 5-, and 10-year RS was approximately 99, 94, and 92%, respectively. RS was highest for patients who underwent surgical procedures or radiotherapy and considerably lower for patients with ADT. CONCLUSION: Our data show that today AS/WW is an option not only for patients with a life expectancy of < 10 years but also for younger men with localized PCa. PCa patients have a good RS if the cancer is diagnosed at an early stage.

DOI: https://doi.org/10.1159/000477096

Originally published at:
Matthes, Katarina L; Limam, Manuela; Dehler, Silvia; Korol, Dimitri; Rohrmann, Sabine (2017). Primary treatment choice over time and relative survival of prostate cancer patients: influence of age, grade, and stage. Oncology Research and Treatment, 40(9):484-489.
DOI: https://doi.org/10.1159/000477096

Oncology Research and Treatment

Original Article

Oncol Res Treat 2017;40:484–489
DOI: 10.1159/000477096

Received: November 24, 2016
Accepted: April 27, 2017
Published online: August 17, 2017

Primary Treatment Choice Over Time and Relative Survival of Prostate Cancer Patients: Influence of Age, Grade, and Stage

Katarina L. Matthes[a,b] Manuela Limam[a,b] Silvia Dehler[a,b] Dimitri Korol[b] Sabine Rohrmann[a,b]

[a] Division of Chronic Disease Epidemiology, Epidemiology, Biostatistics and Prevention Institute, University of Zurich, Zurich, Switzerland; [b] Cancer Registry Zurich and Zug, University Hospital Zurich, Zurich, Switzerland

Keywords

Prostate cancer · Treatment · Survival analysis · Cancer registry · Time trends · Active surveillance

Summary

Background: The aim of this study was to assess associations of stage, grade, and age with the primary treatment of prostate cancer (PCa) patients comparing the incidence years 2000/2001 and 2012/2013, and to estimate the relative survival (RS) for patients diagnosed in 2000/2001. **Methods:** We included 1,541 men diagnosed in 2000/2001 and 1,605 men diagnosed in 2012/2013. Multiple imputation methods were applied to missing data for stage and grade. Multinomial logistic regression analyses were used to explore the associations of stage, grade, and age with treatment. RS was estimated using the Ederer II approach. **Results:** In 2000/2001, older patients were more likely to choose active surveillance (AS)/watchful waiting (WW) or to receive androgen deprivation therapy (ADT) compared to surgery; in 2012/2013, this association was only observed for ADT but not for AS/WW. In 2000/2001, the overall 1-, 5-, and 10-year RS was approximately 99, 94, and 92%, respectively. RS was highest for patients who underwent surgical procedures or radiotherapy and considerably lower for patients with ADT. **Conclusion:** Our data show that today AS/WW is an option not only for patients with a life expectancy of < 10 years but also for younger men with localized PCa. PCa patients have a good RS if the cancer is diagnosed at an early stage.

Introduction

Prostate cancer (PCa) is the most frequently diagnosed cancer in men in Switzerland. Approximately 6,000 new PCa cases are diagnosed each year in Switzerland, of which about 1,000 are registered in the Canton of Zurich [1]. In the last decades, the number of incident cases has increased in Switzerland. One reason is the introduction of the PSA (prostate-specific antigen) test, which leads to a higher number of men being diagnosed with PCa at an early stage. A number of these tumors would remain undetected without the PSA test or would be detected at later stages [2]. It has been shown that only 3% of men diagnosed with PCa die of the disease, and only 16% of men having localized PCa benefit from treatments such as surgery or radiotherapy [3]. Many patients suffer from severe adverse effects of treatment such as incontinence or impotence after surgery. In fact, recommendations state that only patients with a life expectancy of more than 10 years should be treated, whereas patients with localized PCa with a life expectancy shorter than 10 years should be placed under watchful waiting (WW) only [4, 5]. Current guidelines recommend, in addition to WW, active surveillance (AS) as a suitable treatment for low-risk patients with a long life expectancy [6, 7]. The estimation of the long-term relative survival (RS) of PCa patients compared to the general population based on factors such as age, treatment, stage, and grade helps to provide information regarding the suitability of different treatments for patients and, thus, to avoid over-treatment and preserve quality of life. Ladjevardi et al. [8] evaluated the RS of PCa patients in relation to Gleason score and treatment using data of Sweden's National Prostate Cancer Registry. However, to our knowledge, only few studies investigated the association of age, stage, and grade with treatment choices compared to the recommendations of published guidelines and estimated RS rates of PCa patients with respect to primary treatment. Furthermore, the inclu-

S. Dehler current address: Abteilung Gesundheit, Kantonsärztlicher Dienst, Bachstrasse 15, 5001 Aarau, Switzerland

KARGER

Fax +49 761 4 52 07 14
Information@Karger.com
www.karger.com

Accessible online at:
www.karger.com/ort

Katarina Luise Matthes
Cancer Registry Zurich and Zug
University Hospital Zurich
Vogelsangstrasse 10, 8091 Zurich, Switzerland
katarinaluise.matthes@usz.ch

sion of 2 time periods more than 10 years apart provides insight into changes in treatment choices over time based on age, stage, and grade. The aim of this study was to assess the associations of stage, grade, and age with the primary treatment of PCa patients in the Canton of Zurich, Switzerland comparing the incidence years 2000/2001 and 2012/2013, and to estimate RS based on these factors for patients diagnosed in 2000/2001.

Materials and Methods

Study Population

The epidemiological Cancer Registry Zurich and Zug is the largest in Switzerland covering roughly 1.6 million inhabitants. The Registry was established in 1980 to register every cancer patient in the canton of Zurich (and since 2011 in the canton of Zug). The Registry is almost complete; the percentage of death certificate only (DCO) cases is 1.9% for the period of 1988–2012, and the percentage of morphologically verified cases is 93.2% [9]. We included PCa patients who lived in the Canton of Zurich at the time of diagnosis. PCa was defined based on the ICD-10 coding (International Statistical Classification of Diseases and Related Health Problems). To compare former and current treatment choices, we extracted the data of men diagnosed in the years 2000/2001 and 2012/2013. We restricted our data to patients with PCa as the first primary cancer diagnosis and excluded DCO cases and cases diagnosed at autopsy. Of 1,667 PCa cases in 2000/2001, we excluded 78 DCO cases (4.7%) and 48 cases that were diagnosed at autopsy (2.9%). In 2012/2013, of 1,750 PCa cases, 14 DCO cases (0.8%) and 131 cases diagnosed at autopsy (7.5%) were excluded. Hence, for 2000/2001 we finally included 1,541 and for 2012/2013 1,605 PCa patients. We obtained data pertaining to the patients' vital status from the Citizen Services Departments in the Canton of Zurich. Patients diagnosed in 2000/2001 were followed until death or for a maximum of 10 years after diagnosis, whichever came first. The Registry systematically registers the type of cancer, name, date of birth, sex, place of residence, stage and grade of the tumor, and information regarding treatment. The stage of the tumor was classified based on the TNM classification. We restricted the TNM classification to the T-classification, hereafter called stage, which describes the tumor extent. The pathological stage was used if available; otherwise the clinical stage was used. In many cases, we only had knowledge about the tumor grade but not the corresponding Gleason score; hence, the PCa tumor grade was used. Only the primary treatment of a patient was considered. We distinguished between surgical procedures, radiotherapy, and androgen deprivation therapy (ADT). As we cannot directly distinguish between AS and WW, we defined 1 treatment group for AS/WW. Age was divided into 4 groups (< 60, 60–69, 70–79, and > 79 years).

Statistical Methods

In order to handle missing values for stage and grade, multiple imputation with chained equations (MICE) was applied to impute the incomplete data [10, 11]. The imputation model includes the incomplete variables stage and grade and the complete variables date of diagnosis, age at diagnosis, survival time, vital status, and primary treatment. The missing variables were imputed using a multinomial logit model. Since the fraction of missing stage information in the years 2000/2001 and 2012/2013 was approximately 15 and 5%, respectively, and missing grade information was 7% in both periods, we created 20 complete datasets. For each dataset, the analyses were performed separately and merged afterwards using Rubin's rule [12]. After imputation, we tested for a trend in treatment choices by age, stage, and grade using a chi-squared test for trends in proportions. Multinomial logistic regression analyses were used to assess the associations of stage, grade, and age with treatment choices.

For the diagnosis years 2000/2001, we performed RS analyses. RS is defined as the ratio of the observed and the expected survival. The expected survival was estimated from a comparable general population using the Ederer II approach [13] with a life table for the Canton of Zurich [14]. Mortality rates in the Canton of Zurich for each year were available in 22 age groups. To interpolate the abridged life table, the Elandt-Johnson method was applied [15]. Stratified analyses were conducted by age groups, stage, grade, and primary treatment. All statistical analyses were performed in R (version 3.2.2). The R package 'MICE' [16] was used to impute the missing data, the package 'nnet' [17] to perform the regression models, and the package 'relsurv' [18] to estimate RS rates.

Results

The mean age at diagnosis of men diagnosed in 2000/2001 was 70.1 years (standard deviation (SD) = 9.0, median = 70.0, interquartile range = 12.0). During the follow-up period of 10 years, 833 (54%) of 1,541 men died and 27 (1.8%) were lost to follow-up. The average length of follow-up was 7.7 years (SD = 3.2, median = 9.9, interquartile range = 4.6). For the diagnosis years 2012/2013, the mean age at diagnosis was 69.8 years (SD = 9.7, median = 69.0, interquartile range = 12.0).

Table 1 shows the age and tumor characteristics of the patients diagnosed in 2000/2001 and 2012/2013 after multiple imputations stratified by primary treatments. Comparing the years of diagnosis, the proportion of patients undergoing surgery was slightly higher in 2012/2013, whereas the proportion of men with radiotherapy decreased from 11% in 2000/2001 to 3% in 2012/2013. The proportions of ADT and AS/WW were similar in both periods. Stratified by stage, the proportion of men with a T1 tumor was lower in 2000/2001 (28%) than in 2012/2013 (49%), while the proportion of men with a T2 tumor was higher in 2000/2001 (51%) than in 2012/2013 (35%). The proportion of men younger than 60 years of age under AS/WW was 17% in 2000/2001 and 29% in 2012/2013, while the proportion of men older than 79 years of age under AS/WW was 45% in 2000/2001 and 35% in 2012/2013. In 2012/2013, ADT was more frequent for higher-stage tumors (37%) compared to 2000/2001 (16%).

Table 2 presents the associations of age, stage, and grade with treatment choices using the imputed dataset for patients diagnosed in 2000/2001 and 2012/2013. All results were adjusted for age, grade, and stage. In 2000/2001, age was associated with treatment choices indicating that older patients were less likely to have surgery. In addition, AS/WW was more likely a treatment choice for older patients and patients with an early-stage tumor. Furthermore, higher tumor grade was associated with higher odds of receiving ADT compared to surgery. Interestingly, in 2012/2013, age was not associated with treatment choice anymore except for ADT (higher age associated with higher odds of ADT versus surgery). In 2000/2001, there was no association between PCa stage and active treatment, but in 2012/2013, having a stage T4 versus T1 tumor was significantly associated with ADT versus surgery.

Figure 1 illustrates the RS of patients diagnosed in 2000/2001 using the imputed data stratified by age, stage, grade, and primary treatment. Overall, the 1-, 5-, and 10-year RS was 98.5% (95% confidence interval (CI) 97.3–99.6), 93.8% (95% CI 91.2–96.4), and 91.7% (95% CI 87.8–95.7), respectively. The RS of men younger than 80 years was close to 100%, whereas men aged 80 years and older had a lower RS. RS was highest for men diagnosed with a T1

Table 1. Distribution of age and tumor characteristics stratified by treatment

	Total				Surgery				Radiotherapy				ADT				AS/WW			
	2000/2001		2012/2013		2000/2001		2012/2013		2000/2001		2012/2013		2000/2001		2012/2013		2000/2001		2012/2013	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total	1,541		1,605		824	53.5	961	59.9	164	10.64	46	2.9	125	8.1	138	8.6	428	27.8	460	28.7
Age, years																				
< 60	200	13.0	215	14.0	138	69.0	138	64.2	20	10.0	7	3.3	9	4.5	8	3.7	33	16.5	62	28.8
60–69	535	34.7	633	41.1	343	64.1	423	66.8	63	11.8	20	3.2	40	7.5	26	4.1	89	16.6	164	25.9
70–79	574	37.2	486	31.5	249	43.4	282	58.0	78	13.6	15	3.1	46	8.0	51	10.5	201	35.0	138	28.4
> 79	232	15.1	271	17.6	94	40.5	118	43.5	3	1.3	4	1.5	30	12.9	53	19.6	105	45.3	96	35.4
p					< 0.001		< 0.001		0.020		0.238		0.003		< 0.001		< 0.001		0.037	
Stage																				
T1	429	27.8	761	49.4	193	45.0	321	42.2	33	7.69	19	2.5	25	5.8	45	5.9	178	41.5	376	49.4
T2	780	50.6	538	34.9	470	60.3	446	82.9	86	11.03	12	2.2	53	6.8	30	5.6	171	21.9	50	9.3
T3	270	17.5	265	17.2	134	49.6	182	68.7	35	12.96	13	4.9	37	13.7	48	18.1	64	23.7	22	8.3
T4	62	4.0	41	2.7	27	43.5	12	29.3	10	16.13	2	4.9	10	16.1	15	36.6	15	24.2	12	29.3
p					0.371		< 0.001		0.007		0.072		< 0.001		< 0.001		< 0.001		< 0.001	
Grade																				
1	317	20.6	9	0.6	195	61.5	7	77.8	23	7.3	1	11.1	9	2.8	0	0.0	90	28.4	1	11.1
2	820	53.2	398	25.8	444	54.1	221	55.5	101	12.3	4	1.0	53	6.5	7	1.8	222	27.1	166	41.7
3/4	404	26.2	1,198	77.7	185	45.8	733	61.2	40	9.9	41	3.4	63	15.6	131	10.9	116	28.7	293	24.5
p					< 0.001		0.111		0.348		0.049		< 0.001		< 0.001		0.878		< 0.001	

p = p trend; ADT = androgen deprivation therapy; AS/WW = active surveillance/watchful waiting.

Table 2. Association of primary treatment with age, stage, and grade

	Radiotherapy vs. surgery[a]				ADT vs. surgery[a]				AS/WW vs. surgery[a]			
	2000/2001		2012/2013[b]		2000/2001		2012/2013[b]		2000/2001		2012/2013[b]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age, years												
< 60[a]	1.00		1.00		1.00		1.00		1.00		1.00	
60–69	1.23	0.71–2.15	0.90	0.36–2.25	1.70	0.78–3.70	1.01	0.44–2.36	1.02	0.64–1.62	0.88	0.59–1.32
70–79	2.18	1.25–3.80	0.85	0.32–2.20	2.80	1.28–6.09	2.69	1.20–6.01	2.90	1.86–4.50	0.83	0.55–1.27
> 79	0.21	0.06–0.75	0.38	0.10–1.44	3.92	1.69–9.09	5.02	2.18–11.6	3.65	2.21–6.02	1.00	0.63–1.62
Stage												
T1[a]	1.00		1.00		1.00		1.00		1.00		1.00	
T2	1.04	0.61–1.77	0.35	0.16–0.78	0.91	0.49–1.68	0.57	0.32–1.01	0.49	0.35–0.68	0.09	0.07–0.13
T3	1.42	0.74–2.72	0.81	0.36–1.83	1.72	0.86–3.45	1.68	0.99–2.83	0.60	0.39–0.93	0.10	0.06–0.17
T4	2.19	0.87–5.44	2.93	0.56–15.3	1.45	0.51–4.11	4.69	1.89–11.6	0.57	0.27–1.22	0.84	0.34–2.03
Grade												
1[a]	1.00		–	–	1.00		–	–	1.00		–	–
2	1.87	1.11–3.13	–	–	2.52	1.09–5.80	–	–	1.21	0.87–1.71	–	–
3/4	1.75	0.95–3.22	–	–	6.05	2.57–14.2	–	–	1.44	0.96–2.16	–	–

[a]Surgery, age < 60, stage T1, and grade 1 are the references.
[b]For the diagnosis years 2012/2013, the results are also adjusted for grade, but due to the small number of cases for grade 1, results are not presented.
CI = Confidence interval; OR = odds ratio; ADT = androgen deprivation therapy; AS/WW = active surveillance/watchful waiting.

and T2 tumor but lower for patients with a T3 and especially for those with a T4 tumor. Stratification by tumor grade shows that RS increased over time for men with a grade 1 tumor and that 5- and 10-year RS rates were higher than 100%. However, the RS of men diagnosed with a grade 3/4 tumor decreased from 94.5% (95% CI 91.0–98.0) after 1 year to 59.6% (95% CI 46.4–72.8) after 10 years. Stratification by primary treatment choices revealed that the RS of patients who underwent surgical procedures or radiotherapy was approximately 100% within 10 years, whereas the RS of patients who underwent ADT was considerably lower. The RS of men under AS/WW decreased over time.

Discussion

In this study among PCa patients of a Swiss cancer registry, we observed associations of age, stage, and grade with treatment choices. In general, older-aged patients were more likely to receive ADT or AS/WW versus surgery than younger patients, and men with a T1 tumor were more likely to be under AS compared to men with a higher-stage tumor. Additionally, we noted a shift in the association of age with treatment choices such that in 2000/2001, patients older than 70 years were significantly more likely to undergo radiotherapy or to be under AS/WW compared to surgery, which we did not observe in 2012/2013 (table 2). Furthermore, the earlier PCa is diagnosed, the higher the RS for patients. RS was highest for patients treated with surgery or radiotherapy and considerably lower for patients undergoing ADT.

These findings are in line with former and current guidelines. The 2001 guideline of the European Association of Urology (EAU) [4] and the 2003 guideline of the European Society for Medical Oncology (ESMO) [5] recommended surgery and radiotherapy for men with localized PCa who were younger than 70 years of age, whereas AS/WW was recommended for men with localized PCa over 70 years old. For men with advanced disease and for unfit patients, ADT is a treatment option. Our results reflect these former recommendations, illustrating that surgery was more frequent in men younger than 70 years and AS/WW was an option for men older than 70 years. Comparing the former guidelines with the current EAU guideline from 2013 [7] and the EMSO guideline from 2015 [6], a major change is the recommendation of AS also for patients with localized PCa who have a life expectancy of more than 10 years. Indeed, the number of men under AS/WW in the younger age groups increased remarkably in our study. Our results show that treatment decisions depend on age; however, in addition, they should also depend on life expectancy, which we cannot reflect in our study. Furthermore, we observed that ADT was more frequently a treatment option for advanced-stage and undifferentiated tumors. Between 2000/2001 and 2012/2013, the number of men with a T4 tumor treated with ADT increased from 16 to 37%.

We observed a stage migration from T2 to T1 tumors from 2000/2001 to 2012/2013. This reflects the growing use of PSA screening in Switzerland [19], which leads to a higher proportion of men having a T1 tumor. We hypothesize that, despite the debate about the benefits of PSA screening, men are more aware of PCa and still perform opportunistic testing.

A study from the Munich Cancer Registry in Germany covering the years 1990–2010 reported an increase in men undergoing surgery from 45% in 2000–2004 to 53% in 2005–2010 [20]. Our results confirm the increasing use of surgery, although the proportions in our study are slightly higher. We speculate that the robot-assisted da Vinci surgical system, first introduced in 2000 [21], could have

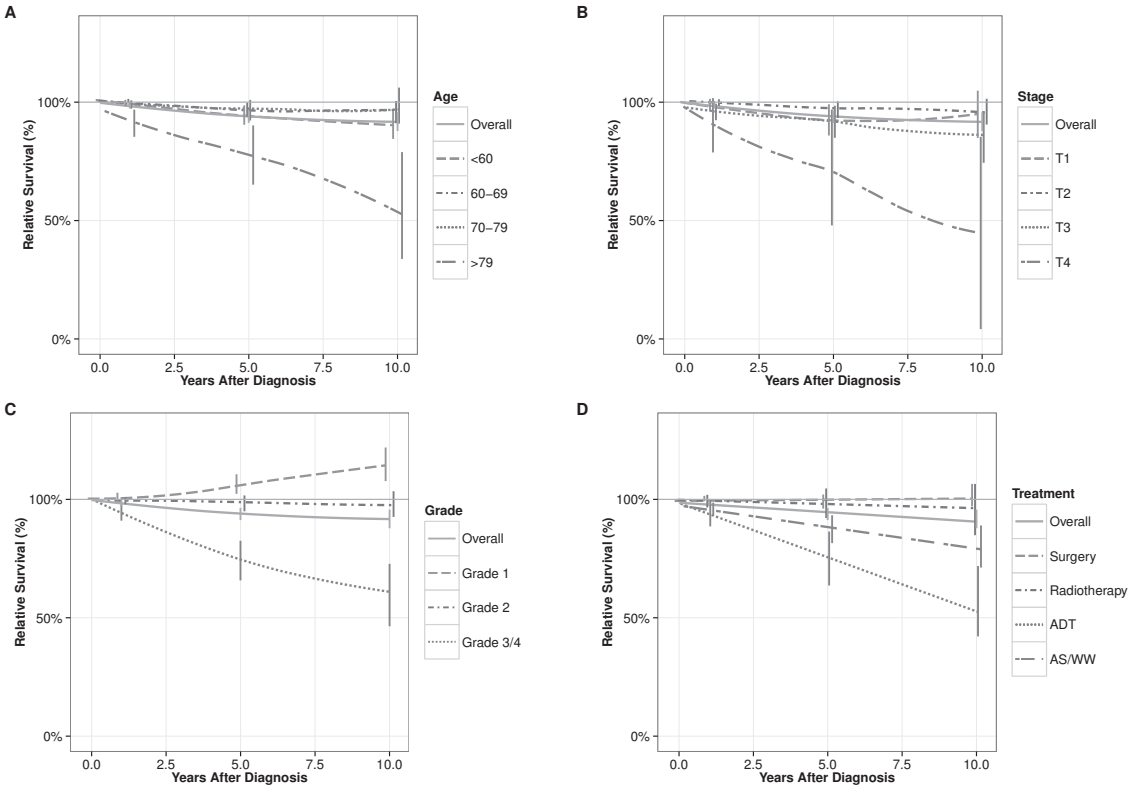

Fig. 1. Relative survival estimates and 95% confidence interval of prostate cancer patients stratified by **A** age groups, **B** T stages, **C** tumor grade, and **D** treatment (ADT = Androgen deprivation therapy; AS/WW = active surveillance; watchful waiting).

an impact on the increasing number of surgeries. The proportion of men who underwent ADT was much higher in Germany, namely 29% in 2000–2004 and 21% in 2005–2010, while the proportion remained constant at 9% in the Canton of Zurich. However, in the Munich Cancer Registry, the number of men under AS/WW was around 20% in both periods, whereas we observed about 28% in the Canton of Zurich.

Evaluating the RS of PCa patients in Germany revealed an overall 10-year RS of 91% [22, 23], and studies based on US SEER data observed a 10-year RS of PCa patients between 95 and 100% [23, 24]. The RS in our study is comparable with that observed in Germany, but is lower than in the US. Different incidence and stage distributions in the US and Germany may partly explain these differences [23]. In the US, PSA screening was used more frequently and introduced earlier compared with Switzerland or Germany. An earlier detection due to PSA screening and over-diagnosis of asymptomatic PCa postpone the time of death and may result in a longer survival time (lead-time bias) [25].

The results of this study are in line with previous studies from the US and the UK that also reported highest RS for men 60–74 years old [24, 26] (fig. 1A). This observation might be explained the fact that more men in their 60s or 70s had a PSA test [26].

Several German, US, and UK studies observed that the RS of men with localized PCa was higher than 100% and increased over time [22, 24, 26]. We also observed an RS of about 100% for men with a T1 or T2 tumor (fig. 1B) and an RS of over 100% for men with grade 1 tumors (fig. 1C). These high RS rates probably indicate a selection bias [22]. Firstly, PSA screening tends to be used more often by men with a more health-conscious behavior, which implies that men having an early-stage PCa are generally healthier than men of the general population [27]. Secondly, men diagnosed with an early-stage tumor might improve their lifestyle as consequence of this diagnosis, e.g. quit smoking, engage in physical activity more frequently, or change their diet [28]. A third reason could be the influence of the socioeconomic status of the patients. Liu et al. [29] reported that a high socioeconomic status was associated with higher odds of performing a PSA test. Rapiti et al. [30] reported similar results for Geneva, Switzerland.

The low RS of men receiving ADT (fig. 1D) is likely explained by the more frequent ADT use in older men or in men with advanced-stage PCa. Furthermore, ADT could lead to side effects that are related to a higher risk of all-cause mortality [31].

A strength of this study is the almost complete coverage of PCa patients in the Canton of Zurich. Furthermore, we had almost complete vital status information for the patients diagnosed in 2000/2001 to estimate RS. Another strength is the inclusion of 2 time periods (2000/2001 and 2012/2013) which allows for assessing changes in treatment choices over time. However, this study also has some limitations. The grading was not comparable between the periods 2000/2001 and 2012/2013 because in 2005, the original Gleason grading [32] was modified. Gleason score 2–4 (grade 1) should not have been assigned anymore because this diagnosis is poorly reproducible even for experts; in addition, a Gleason score 2 may today be referred to as adenosis, not as PCa. Consequently, grade 1 tumors diagnosed in the years 2000 and 2001 would possibly receive a higher grading today [33]. Furthermore, our treatment information is limited so that we cannot clearly distinguish between AS or WW. In addition, we only have information about

radiotherapy and cannot further subdivide into external beam radiation therapy and brachytherapy. Moreover, we investigated only the first primary treatment. Treatment combinations, neoadjuvant, adjuvant, or postoperative therapies were not reflected in our study. We could also not consider delayed treatments after AS/WW. Furthermore, the presence of other chronic diseases at the time of diagnosis may affect the treatment choices. Unfortunately, we do not have information on co-morbidities of the PCa patients.

Conclusion

In conclusion, our study showed an association of age, stage, and grade with treatment choices as recommended in official guidelines. We illustrated that today AS/WW is not only an option for patients with a life expectancy shorter than 10 years but also for younger men having localized PCa. An increase in AS/WW might help to counteract over-treatment especially of younger patients and those with early-stage PCa. Our findings are consistent with results from previous studies stating that PCa patients have a good RS if the cancer is diagnosed at an early stage. An RS above 100% probably indicates a selection bias due to PSA screening, which tends to be more often used by men with a more health-conscious behavior.

Disclosure Statement

This work was supported by the Kurt und Senta Hermann-Stiftung. Manuela Limam was supported by the Cancer League Zurich.

References

1 Krebsregister der Kantone Zuerich und Zug. Jahresbericht 2015. *www.krebsregister.usz.ch/forschung/Documents/Jahresbericht%202015_onlineversion.pdf*; accessed 19 July 2016.
2 Etzioni R, Penson DF, Legler JM, di Tommaso D, Boer R, Gann PH, Feuer EJ: Overdiagnosis due to prostate-specific antigen screening: lessons from U.S. prostate cancer incidence trends. J Natl Cancer Inst 2002;94:981–990.
3 Frankel S, Smith GD, Donovan J, Neal D: Screening for prostate cancer. Lancet 2003;361:1122–1128.
4 Aus G, Abbou CC, Pacik D, Schmid HP, van Poppel H, Wolff JM, Zattoni F: EAU guidelines on prostate cancer. Eur Urol 2001;40:97–101.
5 Kataja VV: ESMO minimum clinical recommendations for diagnosis, treatment and follow-up of prostate cancer. Ann Oncol 2003;14:1010–1011.
6 Parker C, Gillessen S, Heidenreich A, Horwich A: Cancer of the prostate: ESMO clinical practice guidelines for diagnosis, treatment and follow-up. Ann Oncol 2015;26(suppl 5):v69–77.
7 Heidenreich A, Bastian PJ, Bellmunt J, Bolla M, Joniau S, van der Kwast T, Mason M, Matveev V, Wiegel T, Zattoni F, Mottet N: EAU guidelines on prostate cancer. Part 1: screening, diagnosis, and local treatment with curative intent-update 2013. Eur Urol 2014;65:124–137.
8 Ladjevardi S, Sandblom G, Berglund A, Varenhorst E: Tumour grade, treatment, and relative survival in a population-based cohort of men with potentially curable prostate cancer. Eur Urol 2010;57:631–638.
9 Foundation National Institute for Cancer Epidemiology and Registration. Cancer incidence and mortality in Switzerland by nicer: data and methods. *www.nicer.org/NicerReportFiles2015–2/EN/methods_file/methods.htm#data_quality*; accessed 19 April 2017.
10 Nur U, Shack LG, Rachet B, Carpenter JR, Coleman MP: Modelling relative survival in the presence of incomplete data: a tutorial. Int J Epidemiol 2010;39:118–128.
11 Eisemann N, Waldmann A, Katalinic A: Imputation of missing values of tumour stage in population-based cancer registration. BMC Med Res Methodol 2011;11:129.
12 Rubin DB: Multiple Imputation for Nonresponse in Surveys. New York, NY, John Wiley & Sons, 1987.
13 Ederer F, Axtell LM, Cutler SJ: The relative survival rate: a statistical methodology. Natl Cancer Inst Monogr 1961;6:101–121.
14 Swiss Federal Statistical Office. *www.bfs.admin.ch/bfs/portal/de/index/infothek/lexikon/lex/0.topic.1.html*; accessed 19 July 2016.
15 Elandt-Johnson RC, Johnson NL: Survival Models and Data Analysis. New York, NY, Wiley Series, 1980.
16 Van Buuren S, Groothuis-Oudshoorn K: Mice: multivariate imputation by chained equations in R. J Stat Softw 2011;45:1–67.
17 Venables WN, Ripley BD: Modern Applied Statistics with S, 4th ed. New York, NY, Springer, 2002.
18 Pohar M, Stare J: Relative survival analysis in R. Comput Methods Programs Biomed 2006;81:272–278.
19 Eichler K, Hess S, Riguzzi M, Can U, Brugger U: Impact evaluation of Swiss medical board reports on routine care in Switzerland: a case study of PSA screening and treatment for rupture of anterior cruciate ligament. Swiss Med Wkly 2015;145:w14140.
20 Dorr M, Holzel D, Schubert-Fritschle G, Engel J, Schlesinger-Raab A: Changes in prognostic and therapeutic parameters in prostate cancer from an epidemiological view over 20 years. Oncol Res Treat 2015;38:8–14.
21 Binder J, Kramer W: Robotically-assisted laparoscopic radical prostatectomy. BJU Int 2001;87:408–410.
22 Mathers MJ, Roth S, Klinkhammer-Schalke M, Gerken M, Hofstaedter F, Wilm S, Klotz T: Patients with localised prostate cancer (t1–t2) show improved overall long-term survival compared to the normal population. J Cancer 2011;2:76–80.
23 Winter A, Sirri E, Jansen L, Wawroschek F, Kieschke J, Castro FA, Krilaviciute A, Holleczek B, Emrich K, Waldmann A, Brenner H: Comparison of prostate cancer survival in Germany and the united states: can differences be attributed to differences in stage distributions? BJU Int 2017;119:550–559.
24 Brenner H, Arndt V: Long-term survival rates of patients with prostate cancer in the prostate-specific antigen screening era: population-based estimates for the year 2000 by period analysis. J Clin Oncol 2005;23:441–447.
25 Dickman PW, Adami HO: Interpreting trends in cancer patient survival. J Intern Med 2006;260:103–117.
26 Cancer Research UK. *www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/prostate-cancer/survival*; accessed 24 June 2016].
27 Zeliadt SB, Etzioni R, Ramsey SD, Penson DF, Potosky AL: Trends in treatment costs for localized prostate cancer: the healthy screenee effect. Med Care 2007;45:154–159.
28 Humpel N, Magee C, Jones SC: The impact of a cancer diagnosis on the health behaviors of cancer survivors and their family and friends. Support Care Cancer 2007;15:621–630.
29 Liu L, Cozen W, Bernstein L, Ross RK, Deapen D: Changing relationship between socioeconomic status and prostate cancer incidence. J Natl Cancer Inst 2001;93:705–709.
30 Rapiti E, Fioretta G, Schaffar R, Neyroud-Caspar I, Verkooijen HM, Schmidlin F, Miralbell R, Zanetti R, Bouchardy C: Impact of socioeconomic status on prostate cancer diagnosis, treatment, and prognosis. Cancer 2009;115:5556–5565.
31 Nanda A, Chen MH, Braccioforte MH, Moran BJ, D'Amico AV: Hormonal therapy use for prostate cancer and mortality in men with coronary artery disease-induced congestive heart failure or myocardial infarction. Jama 2009;302:866–873.
32 Gleason DF: Classification of prostatic carcinomas. Cancer Chemother Rep 1966;50:125–128.
33 Epstein JI, Allsbrook WC Jr, Amin MB, Egevad LL: The 2005 international society of urological pathology (ISUP) consensus conference on Gleason grading of prostatic carcinoma. Am J Surg Pathol 2005;29:1228–1242.